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AUTHOR Bowles, Anna; Boss, Marvin W.
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ABSTRACT

This study hypothesized a relationship between field independence and both attitude toward science and achievement in science. Testing instruments were the Concealed Figures Test, the Scientific Attitude Inventory, classroom achievement tests, and the Henmon-Nelson Test of Mental Ability. Using the Concealed Figures Test, two extreme groups, one field-dependent and the other field-independent, were identified. It was predicted that, with mental ability controlled, field-independent subjects would score higher on the achievement tests and have a more positive attitude toward science. A multivariate analysis of covariance confirmed the prediction. (Author)

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EXTENT OF PSYCHOLOGICAL DIFFERENTIATION AS RELATED TO ACHIEVEMENT IN SCIENCE AND ATTITUDE TOWARD SCIENCE

by Anna Bowles and Marvin W. Boss,
University of Ottawa,
Faculty of Education,
Ottawa, Ontario,
Canada.

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Witkin's concept of field dependence-field independence is attracting interest and stimulating much research. It appears to provide an objectively measureable dimension of cognition which has important implications for personality and academic achievement studies. Witkin attributes certain characteristics to field-independent subjects, also referred to as analytical subjects. These characteristics are distinctly different from characteristics possessed by field-dependent subjects. This corcept has been of particular interest to science teachers since science is considered a subject of an analytical nature.

1. Theoretical Framework

The differentiation concept was first developed by Werner. "Differentiation" as stated by Werner[1], stands for increased structuralization and specialization of functions and systems. In his orthogenetic principle, Werner states that during development

> "organization is less differentiated, more homogeneous at earlier levels than at more advanced stages".[2]

Witkin describes differentiation in several ways.[3]

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1. H. L. Werner, Comparative Psychology of Mental Development, New York, International University Press, Inc., 1948, p. 40-46.

2. H. L. Werner, Op. Cit., 1948, p. 56.

3. H. A. Witkin, R. B. Dyke, H. F. Faterson, D. R. Goodenough, S. A. Karp, Psychological Differentiation, New York, John Wiley, p. 2, 1962.

He refers to differentiation, in an all-inclusive sense, as the complexity of a system's structure. When referring to an individual's psychological system, differentiation means the degree of separation of psychological areas, as feeling from perceiving, thinking from acting. When considering the relationship of the surrounding field, a highly differentiated person clearly separates that which belongs to itself and that which is external to self.

A central characteristic of psychological differentiation is style of experiencing. Witkin maintains that

> "Implicit in (his differentiation) hypothesis is the view that greater inner differentiation is associated with greater articulation of experience of the world."[4]

Witkin assumes a very close association between inner and outer differentiation since he implies that a person who has greater inner differentiation tends to see the world in a more analytical manner. Thus it is possible to test his hypothesis of inner differentiation by measuring only the external differentiation.

It should be stated that a highly differentiated person is also referred to as being field-independent or analytical. A less differentiated person is referred to as being field-dependent or global.

Characteristics of field-dependent subjects include

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4. H. A. Witkin, Op. Cit., 1962, p. 9-12.

requiring a long time in finding a familiar figure embedded in a complex design, showing less incidental learning, being more sensitive to the evaluations that others make of them. In contrast field-independent subjects have no problems with embedded figures type tests, show more incidental learning and are more stable in their self-view.

The Witkin battery of tests[5] used to measure field dependence-field independence consists of the Rod- and-Frame Test, the Body Adjustment Test, the Tilting-Room-Tilting-Chair Test and the Embedded Figures Test. From these tests, others were developed which were group administered and thus more suitable for use in a conventional classroom. One such test was The Concealed Figures Test developed by Thurstone.

Certain aspects of Witkin's work are still unresolved issues. One such issue is the degree to which mental ability affects scores from tests of field independence. Zigler[6] maintained that field independence was simply a reflection or extension of general intelligence. He implied that if the general intelligence variable was taken out then the magnitude of certain significant relationships reported would remain relatively undisturbed,

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5. H. A. Witkin, Op. Cit., 1962, p. 36.

6. E. Zigler, "Zigler Stands Firm" in Contemporary Psychology, Vol. 3, No. 11, 1963, p. 450-461.

certain others would be reduced and still others would be eliminated.[7] Witkin argued that high correlations between field-independent tests and various subtests of intelligence tests are inevitable. However, he noted that there was no significant correlation between the perceptual tests and the verbal comprehension factor represented by vocabulary, information and comprehension subtests.[8] Although some researchers have found that tests of field dependence-field independence correlated significantly with tests of mental ability these correlations are small, r=0.24, N=96; r=o.20, N=135. Hence one may conclude that tests of intelligence do not account for a large proportion of the variance in field dependence-field independence.

Witkin acknowledges that there are sex differences in the mode of field approach. Males tend to be relatively more field-independent than females in perceptual situations.[9] This result has been confirmed in the research of DeRussy and Futch[10] and Jackson[11]. There have been several attempts to explain this difference. Witkin proposes a biological explanation[12], whereas, Sherman suggests that cultural

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7. E Zigler, "A Measure in Search of a Theory", in Contemporary Psychology, Vol. 8, No. 4, p. 133-135.

8. H. A. Witkin, Op. Cit., 1962, p. 70.

9. H. A. Witkin, Op. Cit., 1962, p. 214.

10. E. DeRussy and E. Futch, "Field dependence-Independence as Related to College Curricula", in Perceptual and Motor Skills, Vol. 33, 1971, p. 1235-1237.

11. D. Jackson, S. Messick and C. Myers, "Evaluation of group and Individual forms of Embedded-figures Measures of Field-Independence", in Educational and Psychological Measurement, Vol, xxiv, No. 2, 1964, p. 177-192.

12. H. A. Witkin, Op. Cit., 1962, p. 220.

norms are the possible source of the difference in the performance of males and females on the perceptual tests.[13] Thus, one should control for sex differences.

Researchers have considered the relationship between field independence and attitude toward science. Witkin maintains that field-independent children tend to derive a genuine satisfaction out of their activities of science, chess, goint to museums. Further support is generated for the view that highly differentiated subjects genuinely enjoy scientific interests by Pemberton[14]. He concluded that the theoretical and scientific interests exhibited by those who scored high on the Concealed Figures Test were indicative of the pleasure these subjects derived from analyzing.

Few studies have investigated the relationship between achievement and extent of field independence. Witkin maintains that for field-independent children, a consistent "high attainment in school" was prevalent. Vernon showed that school achievement in science yielded significant correlations with field dependence tests.[15]

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13. J. Sherman, "Problem of Sec Differences in Space Perception and Aspects of Intellectual Functioning", in Psychological Review, Vol. 74, No. 4, 1967, p. 290-299.

14. C. Pemberton, "The Closure Factors Related to Temperament", in Journal of Personality, Vol. 21, p. 159-155 , 1952.

15. Vernon, "The Distinctiveness of Field Independence", Journal of Personality, Vol. 40, No. 3, 1972, p. 366-391.

The variables of achievement in science, attitude toward science, and mental ability have been shown to be related by researchers as Martens[16], Harris and Lee[17], and Welch[18]. Hence it would appear that any study related to these variables should consider mental ability as a covariate.

Hence, there is in Witkin's work a basis for hypothesizing a relationship between extent of differentiation and both attitude to science and achievement in science. Witkin identifies field-independent subjects as analytical in nature and field-dependent subjects as global. As a result, one would conclude that with effects of mental ability controlled, students who manifest a field-independent cognitive style have a more positive attitude toward science and are higher science achievers than students who manifest a field-dependent cognitive style.

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16. Bruno Martens, "The Relationship of Intelligence, Attitudes and Study Habits to Academic Achievement", in Canadian Education and Research Digest, 1964, p. 268-272.

17. William Harris and Verlin Lee, "Mental Age and Science Concepts, A Pilot Study", in Journal of Research in Science Teaching, Vol. 4, 1966, p. 275-288.

18. Wayne Welch, "Some Characteristics of High School Physics Students; circa 1968", in Journal of Research in Science Teaching, Vol. 6, 1969, p. 242-247.

METHODS AND DATA SOURCE

The sample included 101 grade nine male students enrolled in science in an academic English-speaking high school in a large Eastern Canadian city. To test the hypothesis, it was necessary to identify the extreme groups on the field dependence-field independence continuum. To ensure against possible overlap (of the extreme groups), the thirty lowest and the thirty highest subjects formed the extreme groups. The Concealed Figures Test developed by Thurstone was used as the field dependence-field independence test. Correlations in the 0.55 range were reported with both Witkin's RFT[19] and the EFT[20]. Witkin has recognized that this a suitable measure of psychological differentiation that has been used in testing and that has yielded consistent results. The Concealed Figures Test is a paper-and-pencil test which can be administered individually or in group form.

Moore's Scientific Attitude Invertory[21] was used to measure attitudes toward science (Table 11). This four point Likert type scale consists of sixty items. Some statements are about the nature of science; some are about how scientists work, and others describe how a subject might feel about science. The test is scored in the positive direction, i.e.

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19. R. Elliott, "Interrelationships Among Measures of Dield Dependence, Ability and Personality Traits," Journal of Abnormal and Social Psychology, Vol. 63, No. 1, 1961.

20. Rudin and Stagner, "Figure-Ground Phenomena in the Perception of Physical and Social Stimuli", Journal of Psychology, Vol. 45, 1958, p. 213-225.

21. Moore and Sutman, "The Development, Field Test and Validation of an Inventory of Scientific Attitudes", in Journal of Research in Science Teaching, Vol. 7, 1970.

the higher the total score, the more positive the attitude toward science. This was the only attitude toward science inventory for which the present author was able to find validation in the literature.

The Henmon-Nelson Test of Mental Ability was administered by the guidance personnel. The results were used as a covariate (Table II).

Achievement in science was measured by the results on three teacher-made multiple choice tests for which the Kuder-Richardson-21's reliability coefficients were 0.74, 0.81, 0.78 (Table I). The achievement score for each pupil was the average z-score which was converted to a T-score (Table II).

To minimize classroom disruption the following procedure was adopted for the research. Students partaking in the study were informed by the researcher as to the general nature of the research. The sample was contained in six classroom groups. Each group met separately as a class at a specified time of day for forty minutes on every day of the week. Each of the classes were held in the same room but at different times. The two tests that were administered by the researcher, the Scientific Attitude Inventory and the Concealed Figures Test, were counterbalanced and written on two consecutive days in the middle of the week.

A multivariate analysis of covariance with field independence-field dependence as the independent variable and both attitude toward science and achievement in science as the dependent variables with mental ability as the covariate was run. The research was run at the 0.05 level of significance. (Table III).

RESULTS AND CONCLUSIONS

With mental ability as the covariate, the variables of attitude toward science and achievement in science are significantly different in the two groups, F=11.67, significant at the 0.05 level. Thus the research hypothesis was supported. After controlling for mental ability, students who manifest a field-independent cognitive style were found to be higher achievers in science and more positive in their attitude toward science than students who manifest a field-dependent cognitive style.

Educational Importance of the Study

1. Further support was accumulated for Witkin's theory of psychological differentiation.

2. A major contribution of this research could be in the grouping of classes, especially for tutorial purposes.

3. This research may provide a means for school boards and teachers for the placement of students and teachers in the proper environment; i.e., the mode of presentation for a particular group might be geared to the perceptual style for that group.

4. This research may provide some early guidelines to secondary school students to the type of curriculum they are inclined.

Table I.-

Reliabilities for the Achievement in Science Tests and Thurstone's Concealed Figures Test as Measured by the Kuder-Richardson-21.

	No. of items in test	Standard Deviation of test	Mean	KR-21 value
Achievement Test 1	25	4.46	15.76	0.74
Achievement Test 2	30	5.69	19.22	0.81
Achievement Test 3	25	4.80	15.97	0.78
Thurstone's Concealed Figures Test	196	23.58	64.19	0.93

Table II.-

Means and Standard Deviations for Age, Achievement in Science, Scientific Attitude Inventory, and Henmon-Nelson Test of Mental Ability.

	Achievement in Science		Scientific Attitude Inventory		Henmon-Nelson Test of Mental Ability		Age in years	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Field Independent Group	51.03	7.6	126.4	14.58	119.8	10.05	14.5	.73
Field Dependent Group	43.7	7.1	110.5	15.48	106.7	10.58	14.6	.22

N = 30 for both groups

Table III.-

Results of the Multivariate Analysis of Covariance with Psychological Differentiation as the Independent Variable, Attitude toward Science and Achievement in Science as the Dependent Variable and Mental Ability as the Covariate

Source	Log (Generalized Variance)	U-Statistic	F-Statistic	Degrees of Freedom	
T(psychological differentiation)	17.64146	0.705771	11.6729	2	56
Covariate	22.77643	0.759250	8.8785	2	56
Error	17.20300				

From the Tables $F(2, 56) = 3.15$, $\alpha = 0.05$.